ENERGY EFFICIENCY TECHNOLOGY IN OFFICE AND COMMERCIAL BUILDINGS

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ABSTRACT

The purpose of this study is to investigate on how the designs of the energy efficiency technology used in the Green building technology for building can be replicated in terms of its performance and application. The energy efficiency technology can be translated to the possible gains in playing the role of reducing the carbon footprint and also the cost savings derived from transferring the EE technology to existing building can encourage all new and future development to actively engage in the Green Building Technology. The saving derived from the implementation of green technology systems implemented in some commercial and office building in Malaysia can be shared to help other developers, Engineers, Architect, and building owners to establish that the building energy systems' particularly the air-conditioning system and its subsystems' is able to play a major role in the possibility of creating awareness of Energy Efficiency technology and eventually cost saving for both commercial and office building in Malaysia. The investigate conducted and data quantify from the 2 scenario; firstly by retrofitting of the existing building and , secondly data from EE designed office buildings', the observation is clear that the energy efficient technology can be replicated and will yield a potential saving s even for existing building owners who have retrofitted their building. Whereas for building that is designed to be energy efficient has demonstrated that there are great possibility of cost saving and at the same time play its part in helping in promoting Green technology as part of their corporate social responsibility's role to provide a clear perspective to Developers to actively utilize Energy Efficient technology in future developments . The simulation results further verify the correctness of the energy saving potential.

ABSTRAK

Tujuan kajian ini adalah untuk menyiasat bagaimana reka bentuk teknologi kecekapan tenaga yang digunakan dalam teknologi Bangunan Hijau untuk bangunan boleh ditiru dari segi prestasi dan penggunaannya. Teknologi kecekapan tenaga boleh diterjemahkan kepada keuntungan mungkin memainkan peranan untuk mengurangkan kesan karbon dan juga penjimatan kos yang diperolehi dari pemindahan teknologi EE untuk bangunan yang sedia ada boleh menggalakkan semua pembangunan baru dan masa depan untuk melibatkan diri secara aktif di Bangunan Teknologi Hijau. Penjimatan yang diperolehi daripada pelaksanaan sistem teknologi hijau dilaksanakan di beberapa bangunan komersil dan pejabat di Malaysia boleh dikongsi bersama bagi membantu permaju lain, Jurutera, Arkitek, dan pemilik bangunan untuk membuktikan bahawa terutamanya sistem dan penghawa dingin sistem tenaga bangunan 'yang subsistem ' dapat memainkan peranan utama dalam kemungkinan mewujudkan kesedaran Tenaga teknologi Kecekapan dan akhirnya menjimatkan kos untuk kedua-dua bangunan komersil dan pejabat di Malaysia. Menyiasat dijalankan dan data kuantiti dari 2 senario; pertama oleh retrofitting bangunan yang sedia ada dan, kedua data dari EE bangunan pejabat direka ', pemerhatian adalah jelas bahawa teknologi tenaga yang cekap boleh ditiru dan akan menghasilkan potensi penjimatan walaupun untuk pemilik bangunan yang sedia ada yang telah dipasang bangunan mereka. Manakala bagi bangunan yang direka untuk menjadi cekap tenaga telah menunjukkan bahawa terdapat kemungkinan besar penjimatan kos dan pada masa yang sama memainkan peranan dalam membantu dalam mempromosikan teknologi hijau sebagai sebahagian daripada peranan tanggungjawab sosial korporat mereka untuk memberikan perspektif yang jelas kepada Pemaju untuk aktif menggunakan teknologi Cekap Tenaga dalam pembangunan masa depan. Simulasi keputusan lagi mengesahkan kebenaran penjimatan tenaga potensi.

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AC	Air conditioning
ACA	Air-conditioning area (m2)
AHU	Air handling unit
ASEAN	Association of south-east Asian nations
BSP	Building simulation program
CA	Common area
CAC EC	Central air-conditioning energy consumption (kWh/year)
CAC EE	Central air-conditioning energy efficiency (kWh/m2/year)
CBECS	Commercial buildings energy consumption survey
CH EC	Chiller system energy consumption (kWh/year)
CH EE	Chiller energy efficiency (kWh/m2/year)
CHWP EC	Chilled water pump energy consumption (kWh/year)
CHWP EE	Chilled water pump energy efficiency (kWh/m2/year)
CPA	Car park Area
CT EC	Cooling tower energy consumption (kWh/year)
CT EE	Cooling tower energy efficiency (kWh/m2/year)
CWP EE	condensing water pump energy efficiency (kWh/m2/year)
DSP	Detailed simulation program
ECM	Energy conservation measurement
EC	Energy consumption
EE	Energy efficiency
EMCS	Energy management and control system
EPA	Environmental protection agency
ESCO	Energy Services Company
EUI	Energy use intensity
FCU	Fan coil unit
GFA	Gross floor area (m2/FT2)

GFA ex cpa	Gross floor area excluding car park area (m2/FT2)
GLA	Gross lettable area (m2/ft2)
HBLC	Heat balance loads calculator
HVAC	Heating, ventilating and air conditioning
LSAC	Standalone air-con of the landlord
M&E	Mechanical and electrical
MEPR	M&E plant room area
M&V	Measurement and verification
OHF	Operating hours factor
OR	Occupancy rate (%)
PC	Personal computer
RCU	Remote control unit
SE	Savings estimate
SP	Saving potential
TSAC	standalone air-con of the tenant

CHAPTER 1

INTRODUCTION

1.1 Background

Buildings are responsible for a significant share of the world's environmental footprint. In the United States, buildings were responsible for 38.9% of total energy consumption and 72% of electricity consumption in 2006. Heating, ventilation, and air conditioning (HVAC) make up the largest portion of commercial building energy use (52%). The second largest use of energy in commercial buildings is lighting, which accounts for 20% of a building's energy consumption on average. Lighting and HVAC improvements therefore represent a significant opportunity for energy efficiency in buildings.[1] In addition to energy use, building occupants in the U.S. use 3.4 billion gallons of water each day, and are responsible for the majority of waste generation. Building-related construction and demolition debris amounts to 169 million tons per year, or approximately 26% of total nonindustrial waste generated. Combined with waste disposed of during operation and renovations, building-related waste constitutes two-thirds of all solid waste generation in the United States.[2] (JIMOH, 2011)

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[1] World Business Council for Sustainable Development, *Transforming the Market,* Energy Efficiency in Buildings, http://www.wbcsd.org/DocRoot/rVDgBRKvPngUrqivMHNM/91719_EEBReport_WEB.pdf

[2] U.S. Environmental Protection Agency, *Buildings and the Environment: A Statistical Summary*, http://www.epa.gov/greenbuilding/pubs/gbstats.pdf

Typical energy breakdown in Malaysian office buildings is 50% for air-conditioning, 25% for lighting and 25% for small power (equipment). In addition, air conditioning energy is not only due to heat from solar gain in building but also due to heat from electrical lighting, electrical equipment, conduction (through building fabric), provision of fresh air in building and people occupancy. Each of these items contributes a significant part to the air-conditioning energy used. Unless air-conditioning is not used at all, it is not possible to reduce energy consumption in building by 50% or more by addressing one item alone.

Due to the rapid technological change in Malaysia on electrical lighting, air-conditioning and availability of cheap energy from the mid-20th century onwards, unhealthy design practices in energy efficiency has crept into building design and operation. Today, one can easily identify hundreds, if not thousands, of items in building design and construction that can be made better to improve energy efficiency in buildings. In fact, many building product suppliers are aggressively marketing building material with claims of energy efficiency for the building.

With so many options available from the market place, it has become quite confusing for building designers. Are all the claims made by suppliers 100% truthful? Is it really possible to save the amount of energy claimed? In addition, due to the complexities of energy efficiency in buildings, it is easy to mislead the market by providing and/or withholding information. One simple example that is often heard in the industry is the 'oversell' of reducing solar gain in building. While it is true that reduction of solar gain in building is a very important part of an energy efficient building but claims of 50% reduction of solar gain in building is not the same as 50% energy reduction in building.

In this document, I will attempt to correct the misinformation in the building industry by providing simple and clear advice on the energy efficiency impact of typical design options already practiced by many architects and engineers in Malaysia. These design options provided are not new to architects and engineers. An attempt is made in this document to provide a general guide on the real and quantifiable benefit of these design options. With the provision of quantifiable benefits, it is hope that decision by architects and engineers for energy efficiency in building can be made quickly if not instantly on a majority of energy efficient design issues.

1.2 Problem statement

More often than not, that a negative connotation or respond is receive on the acceptability and on the implementation of Green Building technology and Energy Efficient technologies in future development. That is still in the minds of most developers, building owners and investors. Too those their main concern is why do they need to invest larger capitol for the benefit and use of their tenant if they were to implement GBI or Green certification?

Looking beyond the mere benefit of the prestige in the name of the building which is certified as Green Building, there are other financial gains to the developers or investors and building owner which they might have over sighted.

This study will look at the possibilities of potential savings in both new Green building and also Energy Efficient technologies installed in older existing build could be a saving for the owners of the building.

1.3 Aims and objectives of the study

The aim and objective of this dissertation are described as follows:

(i) To examine the concept of Green commercial and office building and to identify the main Energy consuming component and systems found in all commercial and office building in Malaysia;

(ii) To identify various Energy saving potential through the installation of Energy Efficient technology adaptable in commercial and office office building and to quantify the amount of potential saving benefited through the installation of EE technologies.

Results of this work should help to demonstrate the effects of some efficiency measures and provide a clear understanding of energy efficiency in buildings and specifically in commercial and office buildings outlining what would be the most feasible renewable technique to be adopted in commercial and office buildings, although there is a large amount of information and products available about energy efficiency in commercial buildings of which some are contradictory. This dissertation aims to provide a clear and quantifiable perspective to Developers, building management companies and professionals to actively utilize Energy Efficient technology in future developments

1.4 Methodology

The comparative study on the prescriptive and performance of each building will vary as there are no two building alike, of which each has its own specific data, requirements, and function and look and feel. Generally, the physical attributes of the building and the M&E installations are not unique to any one building so to follow the same methodology to obtain the necessary data for the study, namely:

(i) Collect data on the attributes of the building and the M&E installation which consumes energy to develop the energy-efficiency indicator(s) and conduct the benchmarking exercise; it is used as the dependent variable;

(ii) Collect data of the building physical and system parameters as the independent variable(s); these variables are selected based on two criteria: First, they were considered as the more influential parameters affecting electricity use, and secondly, they were the “must have” for most buildings;

(iii) Estimate the potential saving roughly and determine whether the building systems path or the whole building performance path is to be adopted;

(iv) Determine the significant indicators among the variables according to the analysis;

(v) Calculate the difference of the saving between retrofit or to design new commercial and office building.

1.5 Limitations of Dissertation

This study faces certain limitations which are given as follows:

(i) Constraints of time;

(ii) Constraints of measurements, resources and access to office buildings have led to a small sample size selected and limited number of buildings. In this study, only 9 buildings were surveyed and investigated. However, this sample size is still adequate for building system benchmarking and energy saving modelling process.

(iii) The average annual office building energy consumption in the last one year of the investigation is assumed as the building baseline energy consumption. This may bring some errors in the saving estimation. But since this dissertation is just a study of energy saving potential, the difference is neglected between the average annual electricity bill of one year and the accurate baseline value. Information obtained from office buildings managers may not be absolutely accurate. In addition, information such as area, equipment operation schedule is calculated manually and it is inevitably subjected to a degree of human error.

1.6 Organization of the dissertation

Chapter 1 presents the background of the study, research aims & objectives, scope and limitations of the study.

Chapter 2 introduces what Green building is about, its system components installed in commercial and office buildings and energy performance in Malaysia. The issues highlighted in this chapter include the definition and classification of commercial and office buildings, types and nature of office building systems' energy consumption, office building energy performance; the benchmarking and energy consumption estimation is also described here. An outline provided for the research methodology to be used in this dissertation. It also describes the selection process of office and commercial buildings.

Chapter 3 describes on the data gathering and mode to obtain the data from various sources. The details data collate on the various parameter is analysis for the commercial and office building's Energy performance with reference the building's energy consuming systems partially for the central air conditioning systems and other related sub-systems. The basis of the sampling and the type of sampling is considered.

Chapter 4, outline the analyses of the data obtain from the field and presented it in a comparative analysis on the energy saving potential of each category of buildings. The basis of the surveyed Buildings and the type of sampling is considered to effectively gauge the effectiveness of energy consumed verses the energy efficiency technology employed in building.

The potential saving is demonstrated in this chapter with references to the various calculated methods and through the benchmark method to quantify the potential cost saving in implementing energy efficient technology either through retrofitting of older and existing buildings or to design build that are meant to be Green building with the EE installations in the building.

Chapter 5, in the chapter the conclusion and recommendation is draw conclusively that the study objectives are met and that the potential saving is possible with a summary of the main findings, contributions and recommendations for future studies and the limitation of the current study.

BIBLIOGRAPHY

ASHRAE. (2002). Guideline 14-2002: Measurements of energy and demand savings. *American society of heating refrigeration, and air-conditioning engineers, Inc.,* .

ASHRAE. (2010). Ventilation for Acceptable Indoor Air Quality. *ASHRAE Standard 62.1-2007* .

Chin, C. T. (2012). Detailed Study and Report on the Current Building Designs and EE Building Applications - Draft. *Building Sector Energy Efficiency Program (BSEEP).*

Claridge, D. E. (1994). Can You Achieve 150% of Predicted Retrofit Savings? Is it Time for Recommissioning?,. *Proceedings of the 1994 ACEEE Summer Study* .

Commission of EU. (2003). DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings. *Official Journal of the European Communities*.

Danish Agency for International Development (DANIDA). (2005). Overall Thermal Transfer Value OTTV.

David E. Claridge, M. L. (1996). Implementation of Continuous Commissioning in the Texas LoanSTAR Program: ''Can You Achieve 150% of Estimated Retrofit Savings'' Revisited. *American Council for an Energy Efficient Economy.*

Hong, T. Z., Chou, S. K. and Bong, T. Y. (2000). Building simulation: an overview of developments and information sources. *Building and Environment* .

Hong, T. Z. (2000). Building simulation: an overview of developments and information sources. *Building and Environment* .

JIMOH, B. (2011). *ENERGY EFFICIENCY TECHNOLGIES FOR BUILDINGS: POTENTIAL FOR ENERGY, COST, AND CARBON EMISSION SAVINGS. CLAREMONT McKENNA COLLEGE* , 2.

Lee, S. E. (2004). Performance Benchmarking and Enhanced Energy Efficiency of Buildings,. *Paper presented at the International Congress on Architecture and Technology, Technology,.* Frankfurt, Germany.

Melchert, L. (2007), The Dutch sustainable building policy: A model for developing countries. *Building and Environment* 42, pp. 893–901

Report for the APEC Energy Working Group. (11-12 May 2011). PEER REVIEW ON ENERGY EFFICIENCY IN MALAYSIA. *APEC- Draft Final Report* .

Sharp, T. (1992). Energy Benchmarking In Commercial Office Buildings.

Toh, E. S. (2000). An energy assessment method for office buildings in Singapore,. *Master thesis, Department of Building, National University of Singapore* .

Urban Redevelopment Authority. (1998). Real Estate Statistics Series of Urban Redevelopment Authority in Singapore,. *Stock & Occupancy* .

William Chung, Y. H. (2005). Benchmarking the energy efficiency of commercial buildings. *Applied Energy 83 (2006) 1–14* .

William J. Kennedy, B. L. (2003). *Guide to energy management -Fourth Edition.* The Fairmont Press.